



# ALABAMA AGRICULTURAL AND MECHANICAL UNIVERSITY

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DEPARTMENT OF CIVIL ENGINEERING

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AFOSR-TR- 95 0088  
November 29, 1994

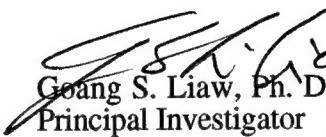
Dr. Marc Q. Jacobs  
AFOSR/NM  
110 Duncan Avenue, Suite B115  
Bolling AFB, DC 20332-0001

Dear Dr. Jacobs:

Enclosed are six copies of Final Technical Report in fulfillment of the Grant F49620-93-1-0601, entitled "Graphics Supercomputer for Computational Fluid Dynamics Research" for the period of 30 September, 1993 through 30 September, 1994.

If you need additional information, please feel free to contact me at (205) 851-5565.

Sincerely,

  
George S. Liaw, Ph. D.  
Principal Investigator

  
Jeanette Jones, Ph. D.  
VP for Research and Development

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## REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0168

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Processing, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0168), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
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FINAL/30 SEP 93 TO 29 SEP 94

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
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GRAPHICS SUPERCOMPUTER FOR COMPUTATIONAL FLUID DYNAMICS RESEARCH

6. AUTHOR(S)	5. FUNDING NUMBERS
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PROFESSOR GOANG LIAW

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	5. FUNDING NUMBERS
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ALABAMA AGRICULTURAL & MECHANICAL UNIV  
DEPT OF CIVIL ENG  
NORAML, ALABAMA 35762

4276/AS  
F49620-93-1-06013. PERFORMING ORGANIZATION  
REPORT NUMBER

AFOSR-TR- 95 0088

8. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
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AFOSR/NM  
110 DUNCAN AVE, SUITE B115  
BOLLING AFB DC 20332-0001

F49620-93-1-0601

11. SUPPLEMENTARY NOTES	12. DISTRIBUTION/AVAILABILITY STATEMENT	13. DISTRIBUTION CODE
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12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

13. ABSTRACT (Maximum 200 words)	14. SUBJECT TERMS	15. NUMBER OF PAGES
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The objective of this project is to purchase a state-of-the-art graphics supercomputer to improve the Computational Fluid Dynamics (CFD) research capability at Alabama A & M University (AAMU) and to support the Air Force research projects. A cutting-edge graphics supercomputer system, Onyx VTX, from Silicon Graphics Computer Systems (SGI), was purchased and installed. Other equipment including a desktop personal computer, PC-486 DX2 with a built-in 10-BaseT Ethernet card, a 10-BaseT hub, an Apple Laser Printer Select 360, and a notebook computer from Zenith were also purchased. A reading room has been converted to a research computer lab by adding some furniture and an air conditioning unit in order to provide an appropriate working environments for researchers and the purchase equipment.

All the purchased equipment were successfully installed and are fully functional. Several research projects, including two existing Air Force projects, are being performed using these facilities.

14. SUBJECT TERMS	15. NUMBER OF PAGES
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DTIC QUALITY INSPECTED 4

16. DISTRIBUTION/AVAILABILITY STATEMENT OR CLASSIFICATION	17. SECURITY CLASSIFICATION OF THIS PAGE	18. SECURITY CLASSIFICATION OF THIS REPORT	19. NUMBER OF PAGES IN THIS REPORT
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UNCLASSIFIED

UNCLASSIFIED

UNCLASSIFIED

SAR (SAME AS REPORT)

20. APPROVAL DATE

**Final Technical Report**  
**Grant Number: F49620-93-1-0601**  
**30 September, 1993 - 30 September, 1994**

## **Graphics Supercomputer for Computational Fluid Dynamics Research**

Sponsored: Air Force Office of Scientific Research  
Bolling Air Force Base, DC 20332-0001

Prepared by:  
Dr. Goang-Shin Liaw  
Alabama A&M University  
Normal, Alabama 35762



## TABLE OF CONTENTS

	PAGE
1. Summary . . . . .	1
2. Acquisition of the SGI Onyx Workstation . . . . .	1
3. Equipment Descriptions . . . . .	2
4. System Setup and Networking . . . . .	4
5. Related DoD Research Activities . . . . .	5
FIGURES . . . . .	7

## **1. Summary**

This grant was awarded under the Department of Defense (DoD) Broad Agency Announcement "Infrastructure Support Program for Historically Black Colleges and Minority Institutions (HBCU/MI's)" for the purpose of upgrading the university's research instrumentation in order to improve the capability of universities to perform research in support of national defense. The objective of this project is to purchase a state-of-the-art graphics supercomputer to improve the Computational Fluid Dynamics (CFD) research capability at Alabama A&M University (AAMU) and to support Air Force research projects.

A cutting-edge graphics supercomputer system, Onyx VTX, from Silicon Graphics Computer Systems (SGI), was purchased and installed. Other equipment including a desktop personal computer, PC-486 DX2 with a built-in 10-BaseT Ethernet card, a 10-BaseT hub, an Apple Laser Printer Select 360, and a notebook computer from Zenith were also purchased. A reading room has been converted to a research computer lab by adding some furniture and an air conditioning unit in order to provide an appropriate working environment for researchers and the purchased equipment.

All the purchased equipment were successfully installed and are fully functional. Several research projects, including two existing Air Force research projects, are being performed using these facilities.

## **2. Acquisition of the SGI Onyx Workstation**

Acquisition of the computer system was begun immediately after this project was awarded by DoD in September 1993. According to the State of Alabama regulations, a bid process is required for equipment purchase \$5,000 or above, otherwise, a sole source justification must be complied. After careful review of two state-of-the-art workstations, the Silicon Graphics Onyx VTX graphics deskside workstation and the DEC 3800 workstation, it was concluded that the SGI be selected for this project. The SGI Onyx VTX graphics supercomputer provides unique performance of state-of-the-art Symmetric Multi-Processor (SMP) technology for computing and transform-oriented applications such as CFD, Finite Element Analysis (FEA), high-end Computer Aided Design (CAD), and molecular modeling. Although other systems, such as the DEC 3800, may be networked together with clustering software acting as if they were one big, distributed memory, multi-processor system, however, this technology was not mature and the performance was not proved at that time. The SGI Onyx VTX graphics supercom-

puter also provides unique visualization capabilities such as stereoscopic-viewing in a window, full performance texture mapping and support for multi-sample anti-aliasing, which exceeds the graphics performance of any other system and acknowledged by the industry, government agencies and universities. Table 1 shows comparisons of key features between the SGI Onyx and a DEC 3800 Farm. A computer Code, RPLUS-2D, developed at NASA/Lewis research center, was used to obtain benchmark solutions for flow inside a two-dimensional nozzle. It was concluded that the Onyx VTX system (4 CPU SMP) could provide superior computing power with exceptional graphics capability to support our CFD research. Therefore, the sole source justification was approved.

Table 1. Comparison between Onyx and DEC 3800

	<b>SGI Onyx, VTX, 4×150 MHz-CPU</b>	<b>Kubota DEC 3800 Farm, 2×200 MHz-CPU</b>	<b>Selection</b>
CPU time <sup>1</sup> (Estimated) Compared to CRAY C94	4.15/1.0	4.78/1.0	SGI Onyx
Graphics Capability (Software, Application)	Superior	Fair	SGI Onyx
SMP <sup>2</sup> Parallel Processing	SMP:Yes	SMP:No	SGI Onyx
Configuration	1-Tower, Monitor	2-DEC 3800 Tower, 1-Denali Box, Monitor	SGI Onyx
User Friendly and Support	Excellent	Fair	SGI Onyx

### 3. Equipment Descriptions

The purchased SGI Onyx VTX graphics supercomputer is listed in Table 2. Other purchased equipment, such as PC-486, Apple Laser Printer and Zenith Z-Star EX NoteBook computer are listed in Table 3, Table 4 and Table 5, respectively.

The Onyx system combines a high speed RISC 4400, 4×150MHz microprocessor with

a powerful VTX graphics subsystem. It provides a cutting-edge supercomputing power and visualization capabilities. The 10-BaseT hub and the built-in 10-BaseT Ethernet network card in the PC make the networking possible. The state-of-the-art high quality graphic printer enhances the capabilities of scientific data representation.

Table 2. SGI Onyx VTX System

Description	Cost
Onyx VTX Graphics Deskside, 4MB Texture Memory 19-inch Multi-Scan Tilt-Swivel, Color Monitor 4 × 150 MHz R4400, 128MB Memory, 6 GB SCSI-2 FAST/WIDE Differential Disk, with Video Output, NFS, C, FORTRAN 77 and Power FORTRAN Compiler, IRIX Development Option for IRIS 5.2 CaseVision, VideoCreator, MovieMaker	\$114,733.00
2GB DAT Internal Drive	\$1,625.00
680MB CD-ROM	\$975.00
Pro MP Fortran Dev Bundle (WorkShop Pro MPF, WorkShop, Power Fortran, Fortran 77, IDO)	\$6,496.75
Network File System Software for IRIX 5.2	\$386.75
QUICKSTART: On-site Tutoring and Technical Assistance for Doing SGI System Customization and Administration	\$2,500.00
Full Extended Warranty	\$11,118.75
<b>Total Cost</b>	<b>\$137,835.25</b>

<sup>1</sup> Required CPU time to obtain a benchmark solution for flow inside a nozzle with RPLUS-2D code. The number here does not represent an actual CPU time, it represent the ratio to the CRAY C94.

<sup>2</sup> SMP: Symmetric Multi-Processor

Table 3. PC-486 System

Description	Cost
486 DX2-50 MiniTower Computer; 8MB RAM 128K Cache, 144 MB FD, 420MB 11 ms HD, 14-inch 0.28mm NI SVGA Color Monitor VL/BUS Graphics Accelerator, 2400 Modem Ethernet 10BaseT (RJ45) Network Card w/Driver A4 Tech 3-Button Mouse, 101 Keyboard MS-DOS 6.21, WFW 3.11 One year Warranty-on site Service	\$1,810.00
8 Ports 10 BaseT Hub	\$420.00
20ft Cable with RJ45	\$15.00
AUI-10BT MicroTransceiver	\$40.00
<b>Total Cost</b>	<b>\$2,285.00</b>

Table 4. Apple Laser Writer Select 360

Description	Cost
Apple Laser Writer Select 360 600-dot-per-inch (DPI) Resolution 10-page-per-minute Print Speed 64 Scalable Fonts Simultaneous Connection to Parallel, Local/Talk, and Serial Ports Automatically Switching between PostScript Level 2 and PCL 5 Two Paper Trays included, 50 and 250-sheet Capacity	\$1,535.00
<b>Total Cost</b>	<b>\$1,535.00</b>

#### 4. System Setup and Networking

The SGI Onyx system was installed in May 1994. An IRIS QuickStart short course was provided by SGI in June, 1994. The QuickStart covers system overview, system management, disk management, backup and recovery, and basic networking. The PC is networked to Onyx

system by a 10-BaseT hub. The INTERNET connection has been successfully established through Alabama Supercomputer Center. The NCSA Mosaic software was installed and are fully functional for both PC and workstation.

Table 5. Zenith Z-Star EX NoteBook Computer

Description	Cost
Z-Star EX NoteBook Computer 8MB RAM, 340MB HD, Color Display	\$3,381.00
24/96 Data/Fax Modem	\$88.00
PCMCIA Ethernet 10 BaseT Lan Adapter	\$262.00
Black Nylon Carrying Case	\$53.00
Extended Warranty Upgrade	\$50.00
<b>Total Cost</b>	<b>\$3,834.00</b>

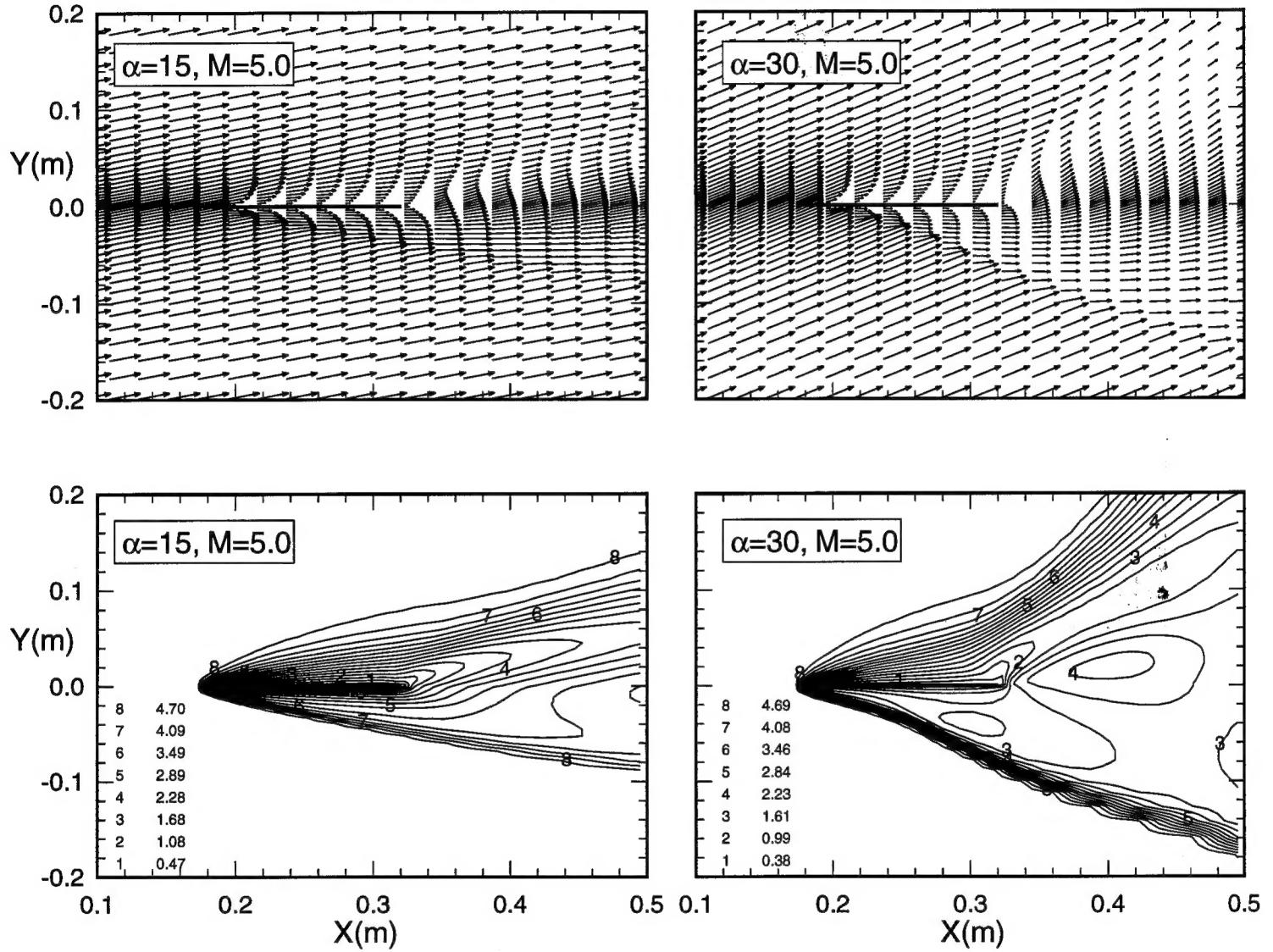
## 5. Related DoD Research Activities

At present time, two major research groups at Alabama A&M University benefit from this computer system. They are CFD group and Computational Structural Mechanics (CSM) group of Civil Engineering department. Both groups rely on supercomputer to provide the computing power to perform the basic and applied research. Two existing DoD research projects are currently using this computer system. A research contract (F33657-93-C-2460), entitled "Viscous Interaction Phenomena in Hypersonic Transitional Flow" is being conducted by the CFD group, led by Dr. G. S. Liaw. This project was funded by the National Aerospace Plane Joint Program Office (NASP) at Wright-Patterson Air Force Base (WPAFB) in January 1994. In this project, a two-dimensional Burnett code BURNETT-2D, and the Direct Simulation Monte Carlo (DSMC) are being developed using the installed workstation. The goal of this project was to investigate the fundamental viscous interaction phenomena for flow over a finite flat plate with angle of attack and flow over a cylinder in hypersonic transitional regime. During the first year of this project, flow over a finite flat plate with an angle of attack was investigated using the developed BURNETT-2D code. Figures 1 shows the velocity vectors and Mach number contours over a flat plate at altitude of 80km. The free stream Mach number is 5.0 and the angle of attack are 15 and 30 degree, respectively. A fast turn-around time was obtained using this system. For example, for the case of 30 degree

angle of attack, in order to obtain convergent solutions, the required CPU time at Cray C94 is about 80 minutes while the overall turn-around time is about one working day. Using the Onyx system with one CPU, the required CPU time is about 1100 minutes. The overall time is less than one working day. With the help of this computing power, this research project will be accelerated significantly.

The other research contract, (F33615-93-C-3209), entitled "Modeling Thermo-Structural Interaction of Composites Including Temperature Dependent Material Properties," is being conducted by the CSM group, led by Dr. P. K. Saha. This project was funded by WPAFB in September 1993. A sophisticated P-version finite element technology for modeling thermo-mechanical and dynamic behavior of laminated composites is being developed. This research work relies heavily on graphical representation of data for evolution and other purposes. This established computer lab is highly beneficial to this project.

Besides the aforementioned computing power, the Onyx system also provide the state-of-the-art pre- and post-processing capability. The scientific data visualization software, such as CaseVision, Explorer for CFD, and 3-D image processing enhance the data representation significantly. The graphic power will be fully utilized in the immediate future which will significantly benefit the ongoing NASP and WPAFB research projects.



**Fig. 1.** Flow over a finite flat plate at angle of attack 15 and 30 degree. Free stream Mach number is 5. This computation was performed using SGI Onyx VTX graphics supercomputer. The graphics is generated by TECPLLOT<sup>TM</sup> using PC-486. The postscript image is printed from Apple Laser Writer Select 360.